ordinary game. Let us place them in a little box, shake them, and throw them on the table. We will assume that they had fallen so that each cube exhibited the number three on its upper face; of course, a rare chance. Now it can be mathematically shown after how many throws those six numbers are likely to reappear according to the law of chance. It is possible that they may turn up already with the next throw; on the other hand, we may have to cast those dice ten thousand times. Both cases are improbable: the probability lies in a certain number. If, instead of six dice, we were to take seven, the critical number is, of course, so much further removed, viz: it would be necessary to throw oftener to get the seven threes, and so the number of casts increases with every additional cube, till we finally obtain enormous figures. But no matter how many dice, the threes must turn up, if we can throw them long enough, and if, in the case of a thousand dice, it were to take a million years, the threes must appear and reappear again and again after proportionate intervals.

Supposing now, that, instead of dice, we were to take a glass filled with sand. There are, let us assume, twenty thousand sand grains in the glass. Each particular grain occupies a certain position, which is bound to differ from that of all the rest of the sand grains: this the reader will doubtless admit. We shake the glass; the positions are altered, the order of arrangement is disturbed. We shake it again; the sand grains are now in a totally different position. We continue shaking the glass, and the time must come when each individual grain again occupies the exact position which it occupied when we originally started. It is a mathematical necessity, which all will admit who know anything of the calculus of permutations. The twenty thousand sand grains may be looked upon as so many dice, which are bound to fall precisely as they once fell if we can throw them sufficiently often.

Now, I have strong grounds for assuming that my body is composed of atoms, or groups of atoms, of a limited number of elementary substances, or of one elementary substance, if all matter has been evolved from one primary element. The number of these atoms may be ever so great, it has nothing whatever to do with the inevitable result. I know also that all other bodies are composed of such atoms, or groups of atoms (molecules); not only those of the human species, animals, and plants, but of inorganic substances, rocks, metals, fluids, gases; in short, of every thing which exists in, upon, or above the ground in the atmosphere. I know, furthermore, that the atoms of even the hardest and seemingly most enduring substances, such as agate and diamond, are in a state of continual vibration; that nothing can permanently retain its form; that the entire universe always has been, is now, and always will be, in a state of metaphorphosis or continual change.

The time must arrive when the atoms or molecules which are now united in my body, after countless transformations and wanderings through all kinds of bodies, substances, or intermediary stages, will once more unite in the same manner; in other words, the time will arrive when my life, like that of every other individual, will repeat itself. Yes, repeat itself, and not merely once, but an infinite number of times.

And more than this, if one of my readers should imagine that the atoms or molecules which now constitute his body, are thus associated for the first time, I can only admire his simplicity. There is nothing new under the sun. Those molecules were united in this manner before, and before this again, and 100,000,000 times previously, as far as our imagination can carry us back into the abysmal night of the æons of the past. In other words, each of my readers has been, ages ago, what he is now, has lived and gone through all this before, has felt and experienced what he now feels and experiences, down to the minutest details, has opened his *Journal of the Franklin Institute* billions of years ago and read the same lines; not once, but an endless number of times. The recollection, of course, is lost. Life and mind itself, consciousness, or "soul," is only a product of matter, and if the same substances reunite in the same manner, the same phenomena must inevitably recur.

Let the molecules which now constitute my body undergo ever so many metamorphoses, let them even — which, of course, is very improbable — once fill a bung-hole, let them be scattered about in all manner of forms and conditions, in close contact or millions of miles apart; they must come together again, may the thought please or distress me, — this is the iron logic of modern dynamics.

A JOURNEY IN COSTA RICA.

AT the February meeting of the Geographical Society of Paris (reported in the Proceedings of the Royal Geographical Society, London) a letter was read from M. H. Pittier, head of the Physico-Geographical Institute of Costa Rica. His route lay through country not previously explored from a scientific point of view. At a distance of several leagues from the capital, the traveller entered the region of oaks, which he hardly quitted for a whole week. The whole of the district known under the name of Candelaria, which, at the time of Œrsted's visit, was well wooded and rich in interesting plants, has become denuded of vegetation through the carelessness of the inhabitants, and is to-day partly covered with a poor kind of turf, over which are scattered clumps of the fragrant bushes of the "tuete" (*Vernonia brachiata*). Beyond the Rio Tarrazu the character of the country changes, and the road ascends in a zigzag line the mountain slopes, covered with forests of virgin oaks. On the summit of the Cordillera the "Paramo del Abejonal," the vast prairie which occupies the ridge of the mountain is crossed, and then a rapid descent was made to San Marcos. From the latter place to the valley of the Rio General is a journey of five days, across the great mountain of Buena Vista, the geographical importance of which has, according to M. Pittier, been overlooked, owing to insufficient exploration. Although inferior in height to the peaks of Irazu and Turialba, Buena Vista presents more sudden changes of climate and a greater variety of vegetation. The summits are almost continuously swept by a keen, strong wind, which condenses thick mists. Sleet falls frequently, and a white frost forms when the nights are clear. The immense forests, which clothe its flanks up to a great altitude, are formed almost exclusively of oaks, among which the most frequent varieties are the *Weinmannia glabra* and the *Drymis Winteri*. The vegetation of the upper region, above the forests, is alpine in character, but the bamboos were found growing beside representatives of an evidently northern flora. At one point, clearly defined formations of columnar basalt were noted. This, with other indications, led the traveller to the conclusion that the whole of the Cerro de Buena Vista is of eruptive origin, although no traces of former volcanoes were descovered. The mountain is important from a hydrographical point of view. The head waters of the Rio Reventazin occupy the greater part of its northern slope; on the west it feeds the Rios Parrita Grande, Naranjo, Savegre, and Baru; while the various branches of the Rio General take their origin from its southern flank. M. Pittier intended to cross the immense forest-covered plains extending on the left bank of the Rio General as far as the Indian villages of Terrata and Boruca, and to return to San José at the end of February. He states that the maps of all this part of Costa Rica are very faulty.

HIGH WINDS AND BAROMETRIC PRESSURE.

THE relation of high winds to barometric pressure, from observations carried out at the Ben Nevis Observatory, was the subject of a paper from Dr. Alexander Buchan, at a meeting of the Royal Society of Edinburgh on March 2, 1891, an abstract of which is given in the *Scottish Geographical Magazine* for May. This was a question, Dr. Buchan said, which had been much discussed in recent years, — some meteorologists maintaining that the influence of high winds was to depress the barometer, others that it was to raise the barometer, and several others, again, that it had practically no effect whatever. In the discussion of the Ben Nevis observations, particularly from the time that hourly observations began to be obtained from the low-level observatory at Fort William, in July last, the first question that appeared to him calling for thorough investigation was this question of the relation of the winds to the readings of the barometer, inasmuch as, till this relation be approximately determined, the proper discussion of

nearly the whole of the observations cannot be satisfactorily proceeded with. This arose from the manifest disturbing influence of high winds upon the readings of the barometer at the top of the Ben. Since the two observatories are only about four miles apart in horizontal distance they are virtually one observatory as regards geographical distribution of pressure; and as the observatory at the top was peculiarly exposed to high winds, the violence of many of which those living on the lower levels could really form no conception, while the low-level observatory at Fort William was much sheltered from winds, the two presented conditions for an exact determination of the question of the influence of winds on the barometer, from data which had not hitherto been available.

The observations at the top were made on Beaufort's wind-scale, ranging from 0, representing the calms, to 12, the greatest hurricane likely to occur. These observations had been carefully compared in connection with the registrations of a modification of Robinson's anemometer, which had been specially constructed by Professor Chrystal to meet the exigencies of observing at the top of the Ben. An elaborate comparison had been communicated by Mr. Omond to a meeting of the Royal Society some time ago, in a paper in which he had arrived at the equivalent in miles per hour for each degree of Beaufort's scale.

The next step followed in the present inquiry was to reduce the observation at both observatories to sea-level, and thereafter to enter the differences between the two barometers in columns headed 0, 1, 2, etc., of Beaufort's scale. This had been done for the six months ending January last; and as it was desirable to increase the number of observations at the higher velocities in order to obtain good averages, the observations made five times daily at Fort William from the beginning of 1885 were compared with those made at the same hours at the top of the Ben, when the wind was at 5 and other velocities up to 11. From these results monthly averages of deviations of the two barometers were deduced, with the result that in all cases a reduced barometer for the top of the hill read lower than that at Fort William, and the amount is proportioned to the force of the wind. Thus, in calm weather the Ben Nevis barometer was only one one-thousandth of an inch lower than that of Fort William, and as the velocity of the wind increased, the depression gradually became greater up to force 4, when it was fourteen one-thousandths lower. From this point it more rapidly increased, till at force 7 the depression was half the tenth of an inch; at force 9, fully the tenth of an inch; and at force 11, a tenth and a half of an inch. These differences, being exhibited in a diagram, showed a remarkable curve of depression corresponding with increased velocity of wind.

The results, Dr. Buchan pointed out, might be put to important uses in meteorology, particularly in endeavoring to establish the relation between the barometric gradient and wind velocity in storms. Hitherto this relation had been attempted to be established from the results as observed, though, it had to be confessed, with not very satisfactory results. Now, however, by applying corrections in accordance with what had been arrived at, this important practical question in meteorology could be attacked with good hopes of success. Dr. Buchan further pointed out, that, as regarded the mean distribution of pressure over the British Isles, the lower pressure hitherto determined at places on the west coast peculiarly exposed to strong winds and storms might be due, not so much to a natural depression of the barometer in these regions, as to the lowering of the barometer by the wind force that swept past the stations where the observations were being made.

HOUSEHOLD REFUSE.[1]

THERE are 750,000 tons of household refuse produced in London every year, and the vestries are at their wits' ends to know how to dispose of it. There is a tradition that large fortunes were once made by dealing with such waste, and the "golden dustman" has passed into a proverb. But if ever this was the case, it has long ceased to be so. Either the quality of the dust has changed, or the former means of dealing with it have ceased to exist, as now it is a source of expense from first to last, and the object of all concerned in its removal is to get rid of it as rapidly and cheaply as possible.

At one time the "destructor" opened a prospect which was full of hope to the parish officials, and they grasped at the idea of burning up all the foul rubbish, and thus getting rid of it once and for all. But that time has passed. The suggestion of establishing a destructor in a district sets all the inhabitants into arms, and gives rise to an outcry that cannot be resisted. In theory the incineration of refuse is beautiful, and it can be carried out fairly well in practice, so long as the apparatus works under favorable conditions. But somehow a breakdown occurs every now and then, and the stink of burning animal refuse pervades the neighborhood. It is very easy to see how this may occur if the fires are allowed to get into bad condition. The collecting vans come in irregularly; sometimes several may arrive together, and, if the men tip their damp contents one after another into the furnaces, there is a great probability of the fires being checked and a volume of smoke given off that does not get completely consumed by the appliances provided for the purpose. Much of the evil may be due to carelessness or want of management, but whatever may be the cause, the destructor has earned for itself a bad name with the public, and it is almost impossible to establish one within the precincts of a town.

The plan that was formerly adopted of laying the refuse, or "dust" as it is called, in heaps and sorting it by female labor, requires a considerable amount of space and gives rise to nuisance. The contents of the heaps, shut out from air and light, putrefy, and when they are turned over, the stench spreads far beyond the limits of the ground. In small places this method is still pursued, but it is no longer practicable in large towns. Such places seek the readiest way of getting the dust right away. If they have access to the sea, they take it a few miles out and dump it into the water, with the result that a good deal of it floats back and litters, if it does not defile, the shore. The London vestries discharge their vans into barges and send the contents down the river to be laid on the Essex and Kentish marshes. Here there is abundant fresh air and only a spare population, so that no harm is done. In course of time nature disintegrates most of the elements of the heterogeneous mass, and when mixed with the vegetable mould of the marshes it becomes a fairly productive soil.

A cursory inspection of the contents of a dust-cart leads to the idea that they are mostly valueless and wholly offensive, or capable of becoming offensive under the influence of time and heat. But this is a mistake, due to the large bulk of the lighter and more ordurous constituents. Such articles as empty meat tins, bottles, waste paper and straw, and vegetable refuse, make a large bulk, but only weigh very little. Three-fourths of the weight of the dust collected consists of fuel. A proportion of this has never been on the fire, while most of the remainder is good cinder; it has had the gases expelled, but the carbon remains and makes capital fuel. Of course there is some thoroughly burned ash, but it is wonderful how much less than one would expect to find. The modern servant is not addicted to the use of the riddle, and all she finds in the grate in the morning goes into the dustbin. This is well known to those interested in such matters, and the brickmakers consequently absorb many thousands of tons of breeze from the dust-carts annually, to the great annoyance of their neighbors; for, although the amount of animal and vegetable refuse is relatively small, it is usually sufficient to taint all the other elements in the dust, and to render them offensive when burnt or handled.

It has been the object of sanitary reformers to discover a method by which the valuable part of the dust could be thoroughly cleaned and turned to account, and the useless parts destroyed without nuisance. A process devised for this purpose is now to be seen in active operation on the premises of the Refuse Disposal Company, Chelsea. It is the invention of Mr. Joseph Russell and Mr. J. C. Stanley, and its salient feature is that the dust is dealt with immediately it arrives, and that, during the whole time it is under treatment, it is kept in motion, and is fully exposed to the air in thin layers. It is tipped from the cart into the machine, and immediately commences its passage through the various sorting devices. In a few moments it has been divided into its different constituents, while all that is offensive has been intimately ground up with

[1] Abstract of an article in Engineering of May 15.